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POTATO YELLOWTOP AND UNMOTTLED CURLY-DWARF IN MAINE

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YELLOWTOP

Near Shirley, Maine, in 1923, a good seed-potato grower, F. A. Phillips, was troubled by a potato disease somewhat different from leafroll or any mosaic in symptoms but like them in that it appeared throughout Green Mountain tuber units. Like leafroll, it caused yellowing and rolling of the foliage, net necrosis of the tubers, and spindling sprouts. Aerial tubers (small green thickened branches along the main stems just above the junctions with the compound leaves) were also a symptom. A visit by the author to Mr. Phillips' place in 1924 resulted in the securing of young plants for experimental work at Aroostook Farm by Dr. E. S. Schultz, who found transmission by aphids and perpetuation by tubers both impossible. A similar disease was found in some Bliss Triumphs from Nebraska, with leaves reddened rather than yellowed, and tuber-grafting to Green Mountains at Aroostook Farm produced the Shirley disease.

At about this time, near Lee, Maine, many similarly diseased hills were observed which were designated as "Rhizoctonia disease" by the growers but which bore no Rhizoctonia lesions and produced many small tubers strung along the underground stolons with net necrosis in some of the tubers. While the net necrosis was similar to that produced by leafroll, the disease was different from leafroll because of the production of aerial tubers. Also there was an increase in the number of tubers and they were produced in the "necklace" effect. Further, net necrosis developed in the field while the tubers were attached to the plant instead of in storage (8, p. 8-9).¹

Also, similar hills were found occasionally on Aroostook Farm near Presque Isle, Maine. These sometimes were characterized by the death of some roots and by a browning of the vascular tissues

¹ Italic numbers in parentheses refer to Literature Cited.

in the lower stem. The browning resembled that of *Verticillium* wilt, then more or less prevalent in Aroostook County, but no organism could be isolated by methods easily successful with *Verticillium*.

The disease was called "yellowtop" and was differentiated briefly (7, p. 23 and Fig. 6) from other nonmosaic virus diseases of Green Mountains in Maine on the basis of distinct dwarfing, spindliness like that of leafroll, extreme chlorosis at times, distinct leafrolling at times, stiff leaf texture, premature death, net necrosis, and sometimes many small tubers mostly strung along the stolons. As stated, the name was used only as being descriptive of a Green Mountain virus disease in Maine. However, the disease also resembled a "yellow-top" degeneration disease described in Montana in 1919 (25).

Although Mr. Phillips' seed stock was unusual in that it gave other growers many mosaic-free seed plots, which were rare in those days, the yellowtop persisted. His records for the seven years 1933 to 1939 showed respectively about 3, 0, 2, 4, 0.5, 9, and 0.5 plants per acre with yellowtop.

At Highmoor Farm, near Monmouth, Maine, yellowtop entered four previously healthy tuber-line seed plots out of five in 1931 and 1932, although the four were isolated from all potatoes containing any yellowtop by distances of 1650 to 1905 feet during the year of infection (6, Table 1). With still greater isolation from any potatoes, seed stock was grown at Highmoor Farm in the six years 1933 to 1938 for planting over 100 farmers' seed plots in all parts of Maine. Yellowtop entered the seed stock at Highmoor Farm in 1934 and 1936 only. Most of the farmers' plots in which yellowtop was found and rogued out, produced seed showing no yellowtop the next year. There were 108 seed plots with no yellowtop in them the first year, and only 3 of them contracted the disease from some outside source (6, p. 248).

Meanwhile Schultz and Bonde working at Aroostook Farm described "apical leafroll" as a new potato disease (17) that resembled witches' broom, being distinguished "by taller, more vigorous, and fewer shoots which form larger and fewer tubers." The witches' broom stock used by them came from Montana, where that disease had been studied by Young and Morris (26). The name "witches' broom" was first used in Minnesota in 1920 (2, p. 30-32), and an appropriate disease for that name was described in detail

by Hungerford and Dana of Idaho and Washington in 1924 (10). Hungerford and Dana thought that Whipple's yellowtop was identical with one phase of witches' broom, and Young and Morris considered Whipple's yellowtop as either rugose mosaic, witches' broom, or a combination of the two.

Also, Leach of Minnesota (14) reported the production of purpletop in potatoes (which looked like Maine yellowtop in his illustrations in color film shown at the presentation of his paper) by using aster leafhoppers (*Macrosteles divisa*) from wild plants. This suggested a form of aster yellows. California aster yellows was transmitted to potato by a leafhopper (23) with some symptoms like those of yellowtop, and from a volunteer potato plant to aster by leafhoppers (22). New York aster yellows was transmitted to potato from *Nicotiana rustica* by the same leafhopper (*Macrosteles divisus*) by Epps (5) and from *Ambrosia artemisiifolia* to potato by this leafhopper by Younkin (27, 28). Younkin characterized the disease on potatoes as causing yellowing on Green Mountains, dwarfing, leafrolling of the youngest leaves, many axillary shoots, some axillary aerial-tubers, root necrosis, lower stem necrosis, and some tuber net necrosis, and as being more easily transmitted with more insects and less easily transmitted to Green Mountains than to other varieties. Severin in California in 1934 (20) used diseased Maine plants in studies that showed the eastern aster yellows to be related to the California aster yellows but not identical. Severin also got witches' broom from California aster yellows on peasant's tobacco (*Nicotiana rustica*) (20, p. 321) but in 1942, even after using Idaho Delphiniums with witches' broom caused by aster yellows, could not conclude that the Idaho aster yellows was the same as the California strain (21, p. 425-426). Kunkel up to 1931 (13, p. 109) had failed in many attempts to transmit eastern aster yellows to potato, and also had failed to transmit potato witches' broom, which he says causes symptoms that are like those of aster yellows on many plants, from potato to aster. He then concluded that "aster yellows is distinct from witches' broom of potato." Kunkel also decided in 1932 (11) that the California and New York aster yellows were not identical in that only the former could be transmitted to celery in his experiments.

Returning now to Highmoor Farm, in 1939 there was a great increase in the number of insects of the species that transmits aster yellows, in the amount of yellows in weeds, garden plants, and

ornamentals, and in the amount of potato yellowtop and potato purpletop. A diseased potato plant was sent to Leach and a statement was received that the stem symptoms resembled somewhat those of purpletop, and that "purple top wilt is not tuber-transmitted."

In 1939 there was an outbreak of aster yellows on various host plants in lawns and flower gardens at Orono, in central Maine, and Bonde also found in Aroostook County many purple-top potato hills, and the insect that transmits aster yellows, both present.

In 1940 at Highmoor Farm, yellowtop appeared in complete tuber units apparently as the result of late 1939 infection and tuber perpetuation. Green Mountain tubers harvested in 1939 from obviously yellowtop hills failed to grow. One such tuber that was not planted was kept until August 7 and had not yet sprouted; it was cut and found to have net necrosis (see Plate 1). A seedling variety, planted with whole tubers, happened to have a yellowtop hill between a healthy hill and a leafroll hill, the diseases having been tuber-perpetuated. These three hills were photographed at different times and are shown in Plates 2, 3, 4, 5, 6, and 7. A green Mountain plant with yellowtop in the upper portion, either from 1940 infection or trace tuber-perpetuation in 1939, was taken up at Lee and photographed July 21, 1940, when the necklace effect of many small tubers was already apparent (see Plate 8). Trace tuber-perpetuation is suggested because this had been found with rugose mosaic to sometimes cause delayed symptoms in the tops of plants (18, Plate 8, C and D). Several yellowtop Green Mountain plants from Highmoor Farm were sent to Dr. L. O. Kunkel. One is shown in Plate 9 as grown by him in the greenhouse. He reported that the disease was not transmitted by a yellows-transmitting species of leafhopper, indicating that the disease was not aster yellows. He further (12) secured transmission of the disease to healthy potato plants, periwinkles (*Vinca rosea*), and sugar beets by means of dodder (*Cuscuta campestris*), and stated that since sugar beets are immune to aster yellows, the disease, which he called witches' broom, was again not the same as aster yellows, although the two diseases looked alike in periwinkles and in tomatoes. Incidentally, he showed that a temperature of 97° F. cured the periwinkles and small potato tubers in a week, and that a temperature of 70 to 80° F. masked the symptoms in periwinkles. This last might

indicate a masking effect in Maine during the few hottest weeks of July and August.

In conclusion, with respect to "yellowtop" in Green Mountains in Maine, it seems that it probably is identical with one or more of a group of similar virus diseases, namely, eastern aster yellows, purpletop, witches' broom, and apical leafroll, besides being sometimes confused with late-season upper-leaf leafroll symptoms from current-season infection. As indicated above, yellowtop potato plants from Maine were shown by Kunkel to have witches' broom which he distinguished from eastern aster yellows only on the basis of susceptibility of sugar beets; yellowtop in Maine was concurrent with an epidemic of aster yellows, and carrot-borne samples of the latter sent to California infected celery, although Kunkel had distinguished eastern aster yellows from California aster yellows on the basis of the eastern type not infecting celery; and Kunkel could not transmit eastern aster yellows to potatoes or witches' broom to asters, whereas California aster yellows was transmitted to potatoes and from potato to aster in California, and New York aster yellows was transmitted to potatoes and from potato through peasant tobacco to aster with the disease assuming the purpletop form or a yellow-top form in potatoes. Yellowtop in Maine, until it assumes greater importance than it has to date, will probably not be accorded detailed study.

UNMOTTLED CURLY-DWARF

Unmottled curly-dwarf was first isolated in potatoes in 1920 through leaf-mutilation inoculations in Maine and was differentiated in Green Mountains from mottled curly-dwarf (a combination of leafrolling mosaic and spindle tuber) and from spindle tuber by Schultz and Folsom (19, p. 60-61 and Plates 10-12; 18, p. 494-496, and Plate 1). The disease lacked the mottling of a mosaic and in comparison with spindle tuber produced more dwarfing, more leaf distortion, more leaf burning, more stem streaking, and more gnarling and cracking of the tubers, and it was somewhat more easily transmitted with the leaf-mutilation method. Goss used unmottled curly-dwarf and spindle-tuber samples from Maine and from the abundant cases that he found in Nebraska for detailed studies in which he confirmed differences found in Maine, and, in

addition, found occasional internal necrosis of the tubers with unmottled curly-dwarf (9, p. 37, Table 7, and Plate 5).

In 1939, Mr. Evan C. Cobb of Lee, Maine, planted several dozen Green Mountain tuber units at intervals in a wild-grass meadow surrounded by lake and woods and situated over a mile from any other potatoes. The writer found all tuber units healthy at the usual roguing time. Some of these tuber-unit-originated stocks or tuber-lines were planted in 1940 in a seed plot, but instead of 100 per cent healthy hills there were some unmottled curly-dwarf hills by July 14. None were found in other seed plots nearby. One mother tuber was still intact and was spindling, gnarled, and cracked in typical fashion for the disease. A survey of neighbors' potato fields disclosed no unmottled curly-dwarf, and to date this is the only instance known of its occurring in Maine outside of the experimental plots near Presque Isle, 100 miles from Lee. Photographs were made of plants with progressive stages of the disease (Plates 10 to 14).

It was noted that there was internal pith spotting in the tubers (Plates 13 and 14) like that described for yellow-dwarf by Barrus and Chupp in New York (1) and by Muncie in Michigan (15). The writer of this bulletin had consulted Barrus soon after the original descriptions of yellow-dwarf and unmottled curly-dwarf and at that time it was agreed that the two diseases were distinct. One specimen of yellow-dwarf was found in Maine in 1935 with a sample sent to New York (3, p. 10); this is the only one known to date in Maine outside of introductions into experimental plots at Orono and Presque Isle. This specimen was found in southwestern Maine, several hundred miles from Presque Isle. The writer had occasion to see many hills of yellow-dwarf in Florida in January, 1939, in samples of New York certified seed which he was examining for the New York chief inspector. Although the evidence was against the Lee disease being anything but unmottled curly-dwarf, the New York authorities were asked for yellow-dwarf tubers with internal necrosis. One of them is shown in Plate 15 between two tubers from the unmottled curly-dwarf plants at Lee. They seem identical and microscopic examination showed that both were cases of pith necrosis and not net necrosis (as in leafroll and yellowtop). This agrees with a description by Walker and Larson of Wisconsin (24, p. 262-263).

The question may arise as to where the unmottled curly-dwarf

at Lee came from into the isolated tuber units in 1939. Yellow-dwarf is known to exist in a number of wild plants (29, 30) some of which are common in Maine, and consists chiefly of two strains of virus, but with two other closely related viruses known, all of which are transmitted by several species of agallian leafhoppers (4) of which some have long been known to occur in Maine (16). The idea seems reasonable that a virus related to yellow-dwarf was transmitted from wild plants by agallian leafhoppers to the potato tuber units at Lee in 1939 causing the disease called unmottled curly-dwarf on potato. Black suggests (4, p. 141) that viruses of the yellow-dwarf type are native American viruses.

CONCLUSIONS

Potato "yellowtop" has been found frequently in Green Mountains and other varieties in Maine, but has not proved serious in twenty years. It probably is identical with one or more of a group of similar virus diseases, namely, aster yellows, purple top, witches' broom, and apical leafroll, besides being sometimes confused with upper-leaf leafroll symptoms from current-season infection.

Potato unmottled curly-dwarf has been observed only once in Maine in commercial plantings and then in a seed plot planted from tuber units isolated in wild grass land. It probably was transmitted to the potatoes from wild plants by agallian leafhoppers which transmit similar virus diseases in the yellow-dwarf group.

Although potato yellowtop in Green Mountains in Maine has not proved serious, conditions may arise which will increase the damage from this disease, as has occurred with leafroll in Aroostook County in recent years after a long period of practical freedom from leafroll. There has been severe injury to the commercial crop from the same or a related disease in other regions. New seedlings are in prospect for commercial growing in Maine, and some of these may be more susceptible to the disease than Green Mountains are.

Similarly, unmottled curly-dwarf in Maine has done no more so far than ruin a tuber-line seed plot for a good seed-grower. An apparently closely related disease, yellow-dwarf, is serious in some regions, and unmottled curly-dwarf has been serious in Nebraska. Changes in conditions, the introduction of seed stocks containing the

disease, or a change to new varieties that are more susceptible than those grown now, may cause the disease to become more common here.

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PLATE 1. Tuber produced in 1939 by obviously yellowtop Green Mountain hill; cut and photographed August 7, 1940. Note net necrosis and absence of sprouts yet.



PLATE 2. Hills of a seedling variety (X237-108) July 9, 1940; from left to right, healthy, yellowtop, and leafroll. See Plates 3 to 7 for later views of the same plants and their crops.



PLATE 3. Same hills as in Plate 2, as of July 22, 1940. From left to right, healthy, yellowtop, and leafroll.



PLATE 4. The healthy hill of Plates 2 and 3, as of August 9, 1940.



PLATE 5. The yellowtop hill of Plates 2 and 3, as of August 9, 1940. Photographed at same distance as healthy hill of Plate 4 and leafroll hill of Plate 6.



PLATE 6. The leafroll hill of Plates 2 and 3, as of August 9, 1940.



PLATE 7. Mother tubers (below in middle) and crops of three hills of Plates 2 and 3; from left to right, healthy, yellowtop, and leafroll.



PLATE 8. Green Mountain plant grown in commercial field near Lee. With yellowtop in upper portion (note leaf on slip of paper at right) and tubers in characteristic yellowtop necklace formation. July 21, 1940.



PLATE 9. Yellowtop Green Mountain plant found at Highmoor Farm and grown later in greenhouse by L. O. Kunkel, who took this photograph. Note many small tubers along stems.



PLATE 10. Green Mountain plant from a commercial field near Lee, with a top leaf (over slip of paper) affected with unmottled curly-dwarf. Photographed July 21, 1940. See Plates 11 to 14 for progressively worse stages of the disease.



PLATE 11. Green Mountain plant from a commercial field near Lee, July 21, 1940, with unmottled curly-dwarf leaves in top, mother tuber at lower left, and new tubers showing spindling form; the latter is characteristic of spindle tuber and unmottled curly-dwarf.



PLATE 12. Green Mountain plant from a commercial field near Lee, August 5, 1940, with a little wilt caused by unmottled curly-dwarf.

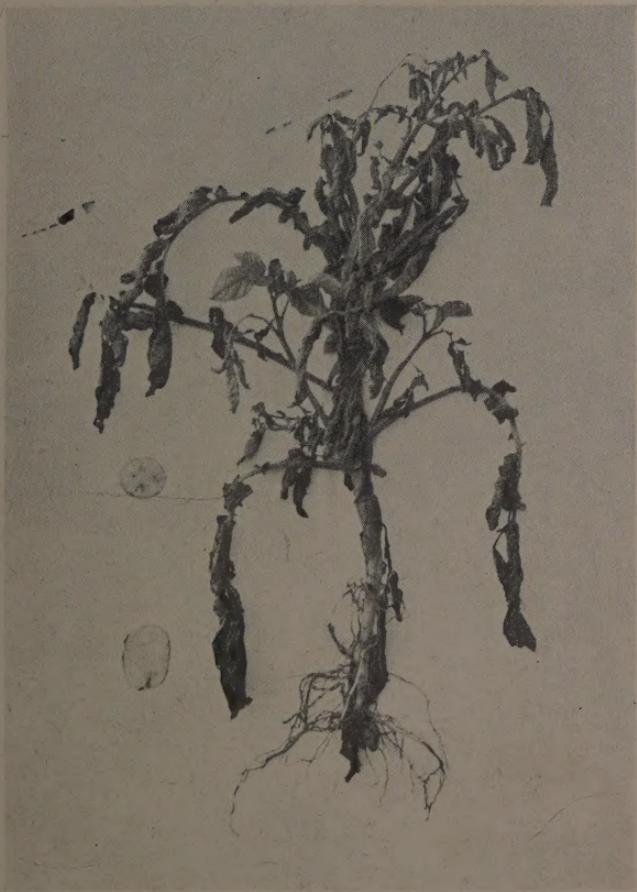


PLATE 13. Green Mountain plant from a commercial field near Lee, August 7, 1940, with wilting due to unmottled curly-dwarf and with tubers cut to show internal pith necrosis.

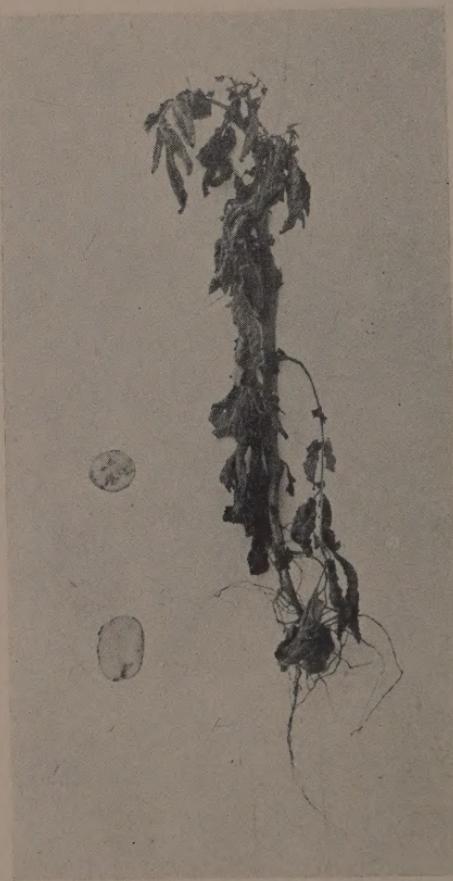


PLATE 14. Green Mountain plant from a commercial field near Lee, August 7, 1940. Wilted due to unmottled curly-dwarf. Tubers cut to show internal pith necrosis.

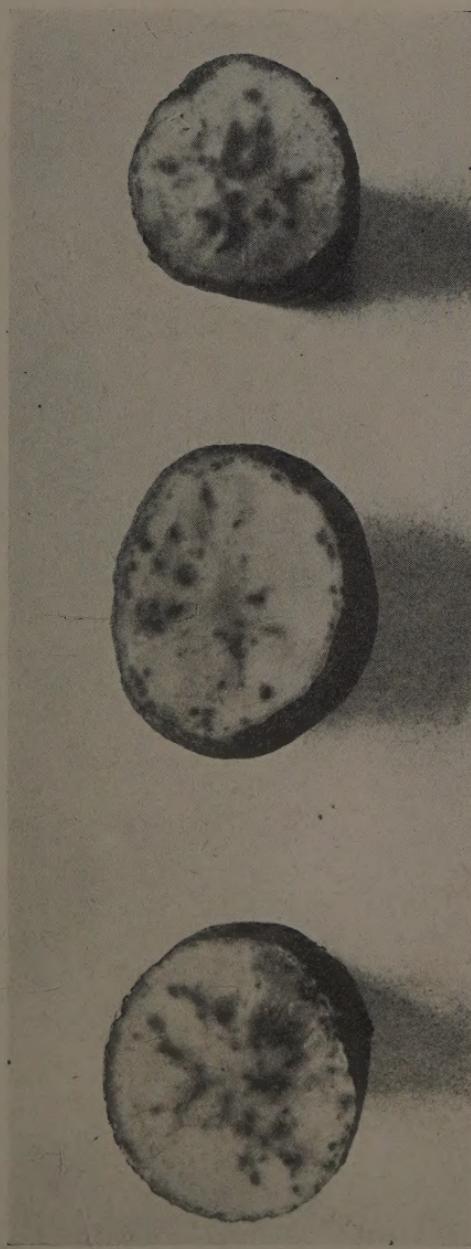


PLATE 15. Potato tubers cut to show internal pith necrosis. Middle, yellow-dwarf from New York. Others, unmottled curly-dwarf from Maine as in Plates 13 and 14.

